Ground Water Report W 20

1963

The Ground-Water Observation-Well Program in Pennsylvania

Charles W. Poth

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
Genevieve Blatt, Secretary
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

BULLETIN W 20

The Ground-Water Observation-Well Program in Pennsylvania

by Charles W. Poth

Geologist

U. S. Geological Survey

Prepared by the United States Geological Survey, Ground Water Branch, in cooperation with the Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY

FOURTH SERIES

HARRISBURG

1963

CONTENTS

ILLUSTRATIONS

TABLE

THE GROUND-WATER OBSERVATION-WELL PROGRAM IN PENNSYLVANIA

By Charles W. Poth

ABSTRACT

The observation-well network in Pennsylvania was established in 1931 to monitor the fluctuations of ground-water levels throughout the Commonwealth. The fluctuations are controlled by geologic, climatic, and hydrologic factors, and by the activities of man. Water-level data from the observation-well network are useful for evaluating the effects of these factors and, therefore, for the intelligent management of the ground-water resources. In 1962 the network in Pennsylvania consisted of 47 wells—some in areas remote from the influence of man and others in areas undergoing urbanization. As funds are available, more wells will be measured, especially in the latter areas, so that the effects of urbanization on ground water may be monitored closely. The new observation wells will be logged electrically and test-pumped, and chemical analyses of the water will be made. All wells will be rechecked periodically for both yield and water quality.

INTRODUCTION

The increasing complexity of modern civilization and the expanding population combine to create an ever-increasing demand for water. To help satisfy this demand, the use of ground water is steadily increasing. Local overdraft of ground-water supplies in some parts of the country has already occurred and has served to focus public attention on the water problem, giving rise occasionally to the erroneous belief that ground water is being depleted everywhere. Each period of dry weather stirs up the rumor anew.

A systematic investigation of the ground-water resources of Pennsylvania was begun in 1925 by the Pennsylvania Geological Survey in cooperation with the Ground Water Branch of the U. S. Geological Survey to obtain information on the source, movement, quantity, and quality of the ground water of the Commonwealth. In 1931, as a result of the interest in ground-water levels aroused by the drought of 1930, a network of wells [1]was established to gather data on the fluctuations of water levels. The locations of the observation wells which composed the network in 1962 are shown in Figure 1.

The observation-well program is a continuing program because a knowledge of the manner in which the levels of natural ground-water

[1]The measurements of the depth to water in wells of this network have been published in U. S. Geological Survey Water-Supply Papers 777, 817, 840, 845, 886, 906, 936, 944, 986, 1016, 1023, 1071, 1096, 1126, 1156, 1165, 1191, 1221, 1265, 1321, 1404, and 1537.

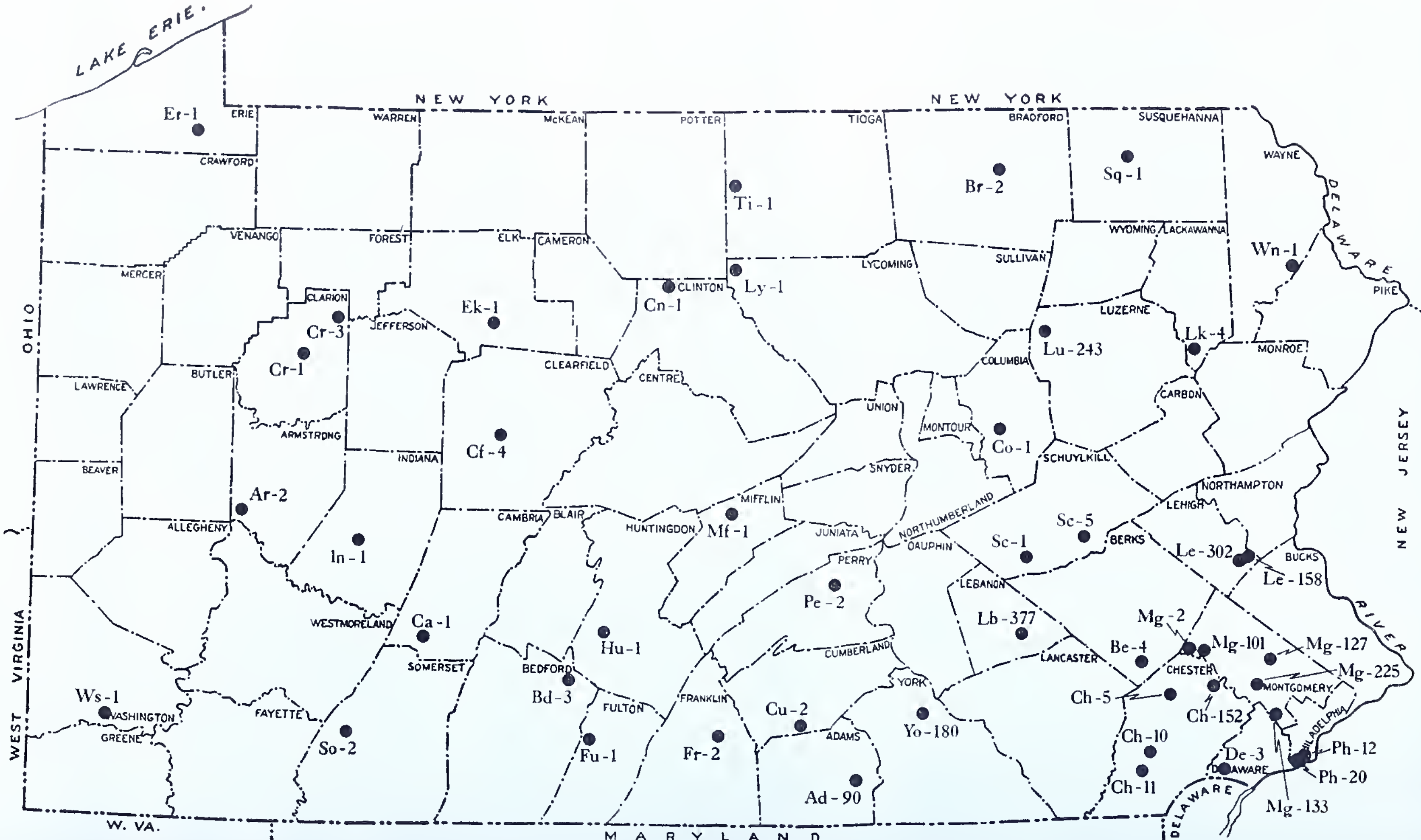

Figure 1. Map of Pennsylvania showing locations of observation wells in 1962.

reservoirs rise and fall—or remain reasonably stable in relation to rainfall, drought conditions, pumpage, and other causative factors—is essential in the study, development, and management of ground-water resources.

This bulletin explains the specific uses of water-level records. It describes the ways in which water levels vary and what these variations mean in terms of adequacy of supply. It also explains the problems involved in locating observation wells that give data representative of a general area. Finally it presents the current observation-well network in Pennsylvania and recommendations for the strengthening of that network.

CAUSES OF VARIATIONS IN GROUND-WATER LEVELS

Geologic factors

The geologic environment in which ground water occurs is a major factor controlling the availability of the water and in determining its chemical and physical character. Because the water occurs in pores and fractures in rocks, the amount of water available to a well is dependent on the number, size, and degree of interconnection of the openings—just as the chemical character of the water is determined by the mineral composition of the rocks. The geology of Pennsylvania is unusually complex and varied—more than 150 formations and many subunits have been recognized—so that the problem of locating a few wells to monitor the wide range of geologic environments is exceptionally difficult.

Climatic factors

The replenishment of ground water in an area depends largely on the climate of the area. The annual precipitation (which averages 42.23 inches in Pennsylvania) is important, but the distribution of precipitation throughout the year and the intensity of precipitation are equally important. Precipitation data for Pennsylvania show that monthly differences are fairly small, although there is approximately 36 percent more precipitation in summer than in winter. Temperature also is important, because it affects the rate of evaporation and transpiration by plants and thereby controls the moisture content of the soil; these factors exert considerable control on the amount of ground-water replenishment during a storm.

The average monthly temperature and precipitation in Pennsylvania are shown in Figure 2. The average annual temperature is 50.2°F.

The change of climate with the passage of time is well known and has long been a subject of study and speculation. Whether the changes (other than the seasonal ones) are cyclic—that is, recurrent at predict-

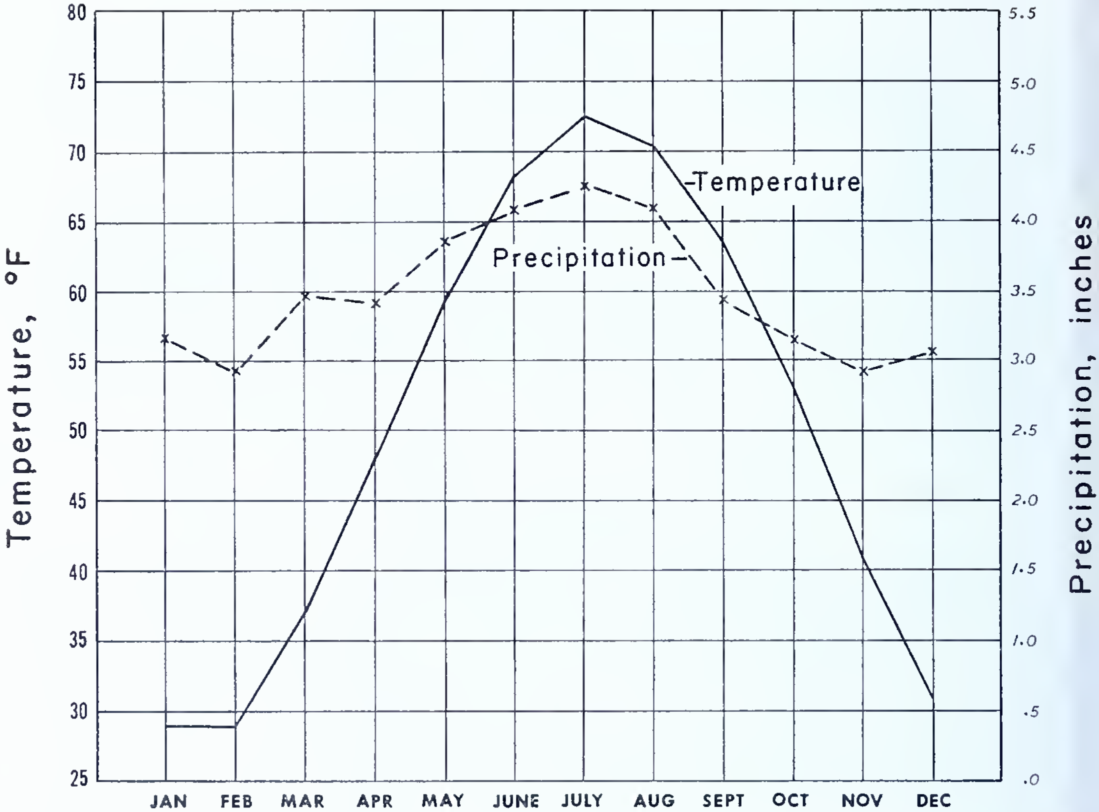

Figure 2. Graph showing the average monthly temperature and precipitation in Pennsylvania. Data from U. S. Department of Agriculture Yearbook of Agriculture, "Climate and Man", 1941.

able intervals—or whether they are simply random fluctuations, is still uncertain. Occasionally, cycles appear to be present in short segments of a record, but they do not recur throughout the record.

Cycles would undoubtedly be due to factors of far-reaching effect rather than of local effect, and neighboring weather stations should have similar records. However, the records of neighboring stations often show pronounced differences, and the wettest year recorded at one station may correspond to the driest year recorded at a nearby station.

Studies of the variability of precipitation from year to year at a station have shown that data for a period of about 30 years are believed to give the true long-term mean rainfall within an average error of about 2 percent; the average obtained from only 5 years of data may be 15 percent in error. In addition, the studies have shown that during wet years the rainfall is 25 to 70 percent greater than average, and in dry years it is 20 to 45 percent less than average. The annual rainfall was found to be above average about 46 percent of the time. In studying the duration of wet and dry periods, scientists have found also that the annual rainfall at a station rarely exceeds or falls below the average for more than 5 or 6 consecutive years.

Hydrologic factors

Only part of the precipitation that falls on the earth's surface becomes ground water. Much of the precipitation may return immediately to the atmosphere by evaporation or flow overland to streams. Even the moisture which does sink into the ground may be adsorbed on soil particles or captured by plant roots before it reaches the zone of saturation to become ground water.

If the upper surface of the ground water is free to fluctuate in response to changing conditions, the water is controlled by water-table conditions, and its upper surface is the water table. If the water in an aquifer (ground-water reservoir) is confined under hydrostatic pressure by relatively impermeable rocks, and the water level in a tightly-cased well tapping the aquifer rises above the top of the aquifer, the water is controlled by artesian conditions. The level to which water will rise in tightly cased wells that tap an artesian aquifer is called the piezometric surface of the aquifer.

Water-level fluctuations.—The water level in wells tapping water-table or artesian aquifers fluctuates in response to several factors. The most important factor is the natural recharge-discharge regimen of an aquifer, by which the water level rises during periods of recharge (Fig. 3) and declines between such periods, as water is discharged from the aquifer. The effectiveness of a given amount of precipitation in recharging an aquifer depends partly on the amount of water adsorbed on soil particles or captured by plants during its movement through the unsaturated zone. Ordinarily, a smaller percentage of the water reaches the zone of saturation in summer than in winter, because of the high rate of evapotranspiration in the summer. This relationship produces an annual cyclic fluctuation in which the water level is highest in the spring and lowest in the fall.

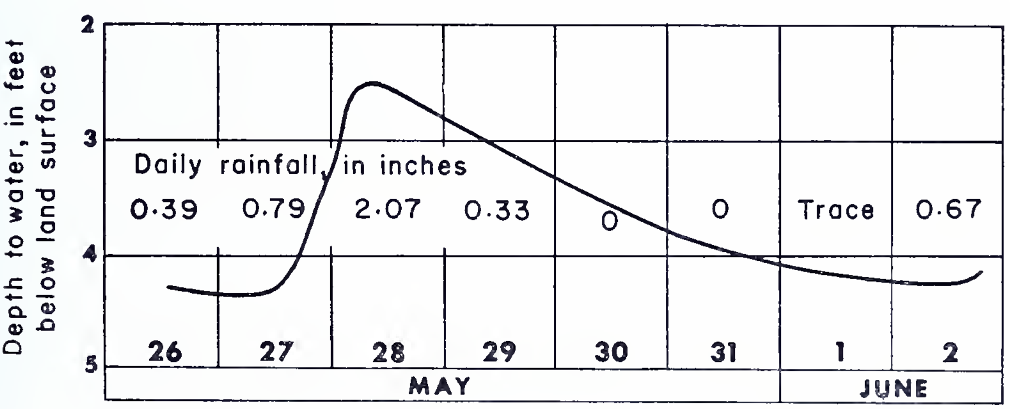

Figure 3. Hydrograph of well Sq-1, showing effect of precipitation, May 26 to June 2, 1946.

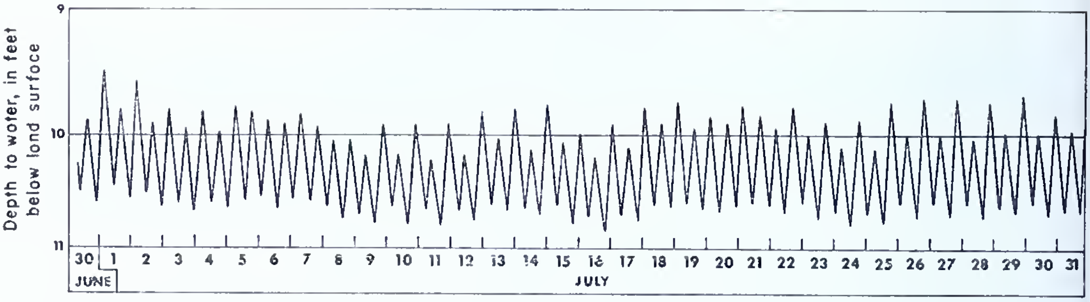

Figure 4. Hydrograph of well Bk-500, showing effects of ocean tides, June 30 to July 31, 1954.

Superimposed on the recharge-discharge cycle are fluctuations due to many other influences. If the water table lies close enough to the land surface, evaporation and transpiration by plants will produce minor diurnal oscillations during the growing season. Transpiration will cease after a killing frost, often with a corresponding rise in the water level. A decline in water level in a shallow aquifer may occur also in winter, as water below the frozen soil is drawn upward by capillarity and is added to the frost layer from below.

Changes in atmospheric pressure produce inverse changes in the water level in artesian wells but no change in water-table wells. In an artesian aquifer, the pressure change is transmitted directly to the water in the well but indirectly (through the confining bed which does not completely transmit the change in pressure) to the water in the aquifer. Hence, an increase in atmospheric pressure will cause a lowering of the water level in the well. In a water-table aquifer the change in pressure is transmitted equally to the water in the well and to the aquifer, and there is no noticeable water-level fluctuation.

The movement of ocean tides causes oscillations of water levels in both confined and unconfined aquifers (Fig. 4) that decrease as the distance from the ocean or tidal inlet increases. Also, earth tides cause small semidiurnal fluctuations in an artesian aquifer.

Pumping of wells or injecting of water into wells may cause considerable change in the water level in an aquifer and in most areas will obscure the fluctuation of water levels due to natural causes. Figure 5 shows the water-level fluctuations in well Mg-4 caused by the pumping in other wells.

The size of any water-level fluctuation depends on the ability of an aquifer to store and transmit water as well as on the magnitude of the forces applied to the aquifer or the amount of water added or removed. Where the storage capacity and transmissibility of an aquifer are large, the size of the water-level fluctuation will be less than where they are small. Furthermore, in any hydrologic system having a common discharge area the amplitude of the seasonal cycle will depend also on

the height of the measuring point (well) above the area of discharge, because the rate at which the ground-water surface declines is proportional to the height of the surface above the discharge point. The water level nearer a hilltop, therefore, will fall more in a given time than the water level on the slope of the hill, and the amplitude of seasonal fluctuations will be greater on hills than in valleys.

Wells in which the water level fluctuates repeatedly over a range of many feet may become clogged by the encrustation of minerals on the walls of the wells. The encrustation forms as the declining water level leaves behind a thin film of water to evaporate and deposit its dissolved solids. After repeated fluctuations, an impervious crust is gradually built up, and the well becomes insensitive to water-level changes in the aquifer.

Long-term fluctuations.—Much of the interest in water-level fluctuations concerns the trends of water levels and the existence of cycles. Figure 6 shows the hydrographs of four representative wells, in widely separated parts of Pennsylvania, for which long periods of record are

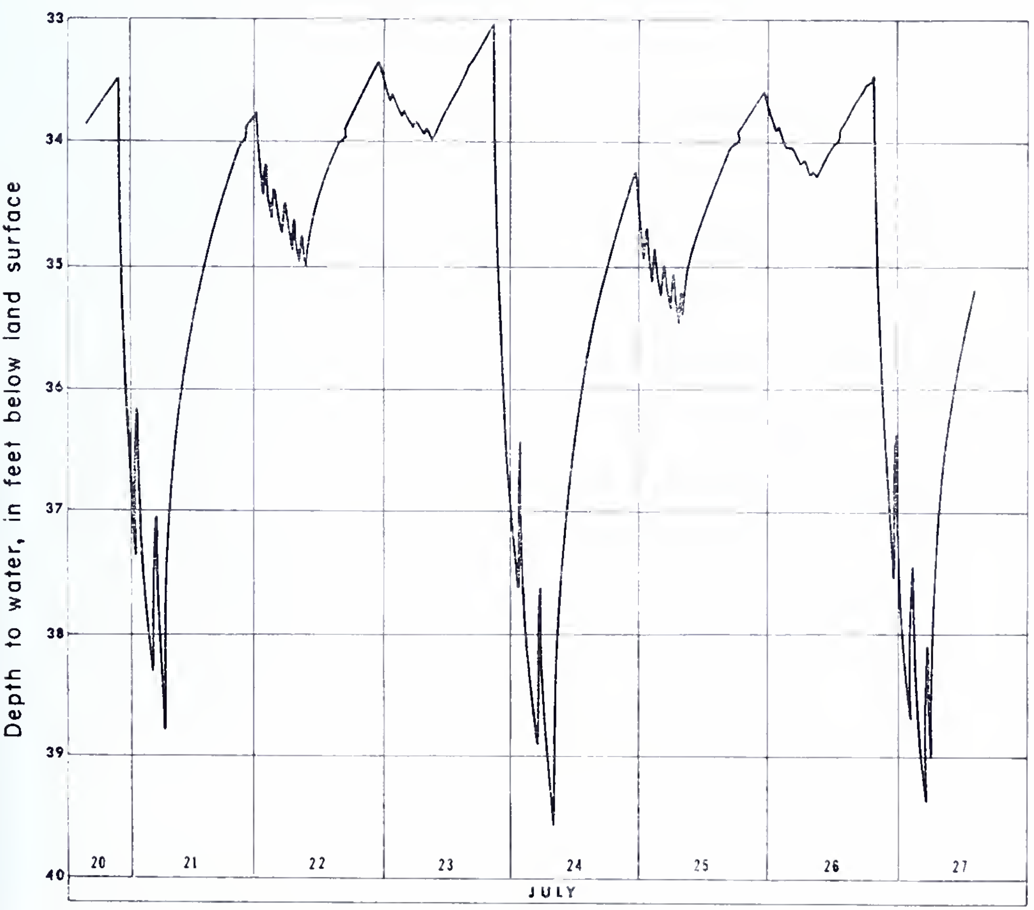

Figure 5. Hydrograph of well Mg-4, showing the effects of pumping in other wells, July 20 to 27, 1956.

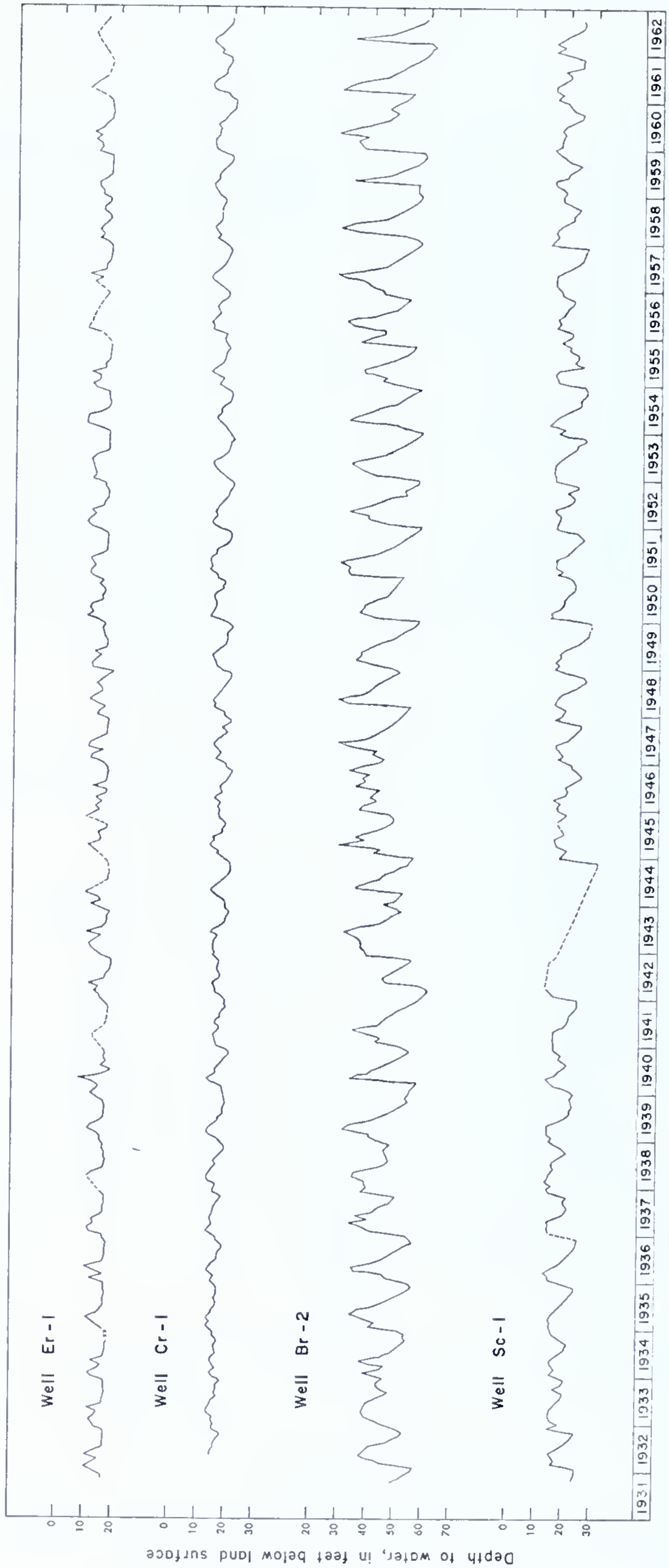

Figure 6. Hydrographs of wells Er-1, Cr-1, Br-2, and Sc-1, showing water-level fluctuations from 1931 to 1962.

available. Inspection reveals that although water levels stand higher in some years than in other no long-term trend is apparent.

The hydrographs in Figure 6 illustrate the behavior of the water table under conditions of dynamic equilibrium. So long as there are no changes in the regimen of these areas, the water table in the vicinity of the wells will continue to oscillate in the characteristic fashion shown in this figure. If this regimen were changed by some factor—either by a change in climate or by some work of man—the water table would respond to this change. If the change were brought about by the pumping of water from the aquifer, the water level would decline until the natural discharge from the aquifer was reduced by an amount equal to the pumping rate, or additional recharge was induced by an amount equal to the pumping rate, or the combined reduction in natural discharge and increase in recharge was equal to the pumping rate.

If the pumping rate were constant, the hydrographs resulting from the new regimen would differ from the old only by the increased depth to water; however, if the rate were irregular, even the pattern of fluctuations would be altered. If the pumping rate were greatest during the late summer and fall, when the ground-water levels are naturally at their lowest, the amplitude of the annual cycle would be greater and might even result in the well becoming temporarily dry. A maximum pumping rate in the spring, when water levels are high, would tend to flatten the hydrograph and reduce the amplitude of the fluctuations.

In order to see more clearly the fluctuations that have a duration greater than 1 year, 12-month moving averages were computed for the water-level data from well Br-2. The 12-month moving average is a series of successive averages obtained by averaging the first 12 monthly water-level measurements to obtain the first average, then discarding the first monthly measurement and including the thirteenth monthly measurement to obtain the second average. This process is repeated through the data. The 12-month moving average removes the effect of cycles 12 months long or even fractional multiples of 12 months, such as 1, 2, 3, 4, or 6 months. The precipitation and temperature data from a nearby U. S. Weather Bureau station were treated similarly. These three curves are shown in Figure 7. The water-level curve resembles the precipitation curve quite closely but differs from the temperature curve. No cycles are apparent in any of these curves.

The average ground-water levels shown in Figure 7 change considerably from year to year. Several years of above-average water levels occur together and are followed in turn by several years of below average water levels, because of the natural changes in meteorologic conditions. The lack of a trend is apparent, and it is important to realize that

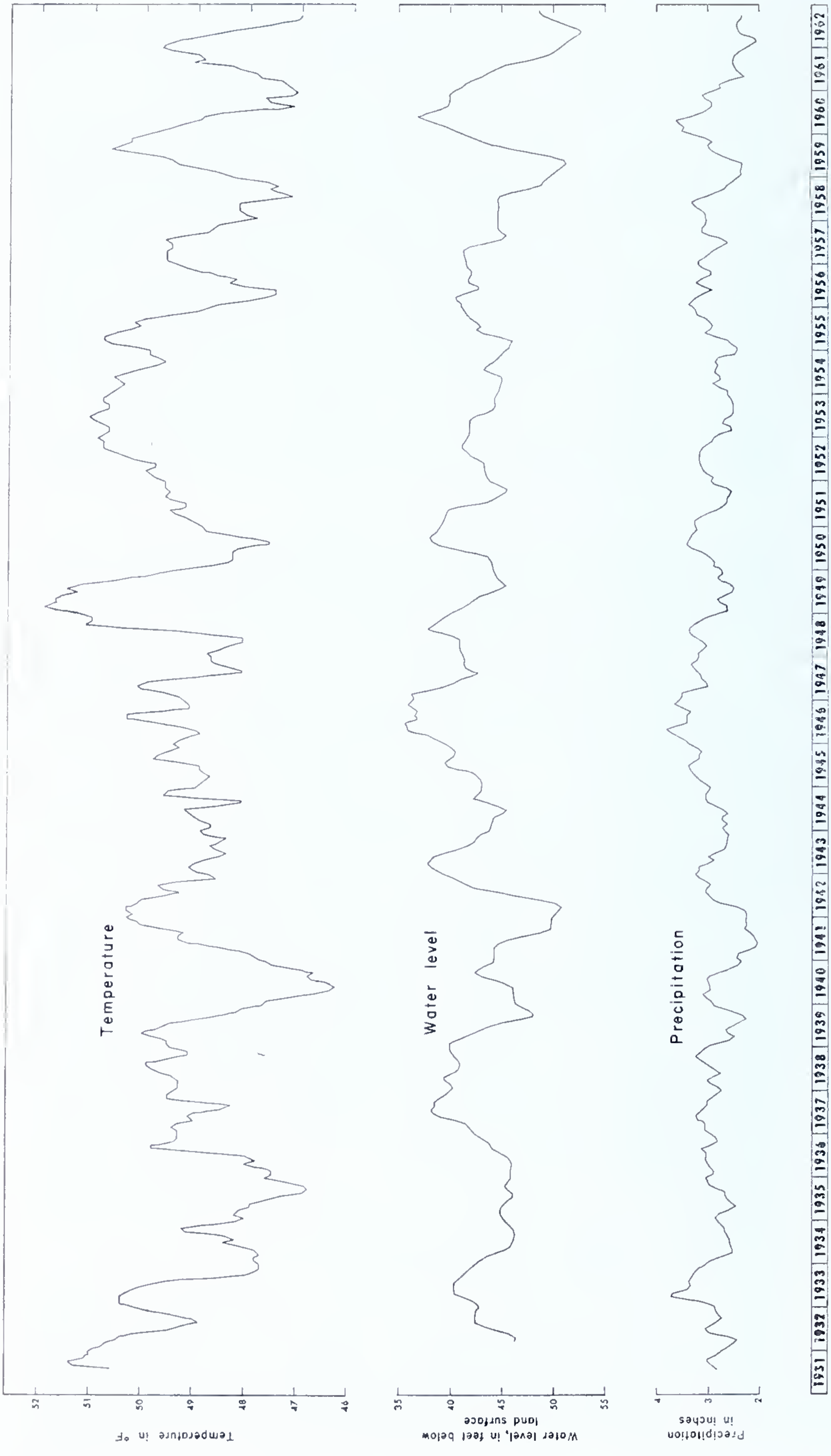

Figure 7. Graph showing 12-month moving averages of water-level data in well Br-2 and temperature and precipitation data at a nearby U. S. Weather Bureau station.

several years of below-average water levels do not indicate that the water levels are permanently declining.

Low water levels may result in some wells going dry; therefore, care should be taken that wells are deep enough, especially in areas where the rocks have low storage capacity or where there is much pumping.

Effects of man

The 1960 census of Pennsylvania reported a population of 11,319,366, which represents a growth of 7.82 percent since 1950. Figure 8 shows counties having more than 100,000 people and the rate of growth of the population by counties. Most of the Commonwealth's population is concentrated in a few areas: the southeast, the anthracite coal-mining region of east-central and northeast Pennsylvania, the bituminous coal-mining region of southwestern and far western Pennsylvania, the Pittsburgh district in central Allegheny County, and the region along Lake Erie.

Significant changes in the distribution of the population took place between 1950 and 1960. Two factors appear to be involved. First, the economic decline of the coal industry caused large numbers of people to seek employment elsewhere, so that some counties had fewer people in 1960 than they did in 1950. Second, large segments of the population moved out of the cities to suburban areas. Thus, while Philadelphia's population decreased about 3 percent, that of nearby Bucks County increased about 113 percent. Counties adjoining Bucks County also showed rates of growth far in excess of the average for the Commonwealth. Most of the other cities in Pennsylvania showed either a loss in population or a growth rate below that of the Commonwealth.

Therefore, it may be inferred that within the foreseeable future the demand for water in the older cities will increase only slowly or may even decrease, but in the areas surrounding these cities the demand for water probably will increase considerably.

Suburban development generally reduces the demand on a single source for water, and draws, instead, upon many sources. Also, the problem of waste disposal in relation to the potential pollution of water is distributed over a much larger area than when the problem was confined to one city.

Furthermore, suburban development disturbs the natural recharge-discharge regimen. By removing forest and grass cover, constructing streets, sidewalks, and buildings, and channeling precipitation to concrete sewers, the aquifers are deprived of water that is needed to replace that which the suburban development is consuming. The net result, then, may be a decline in water levels in these newly developed areas and a deterioration of water quality.

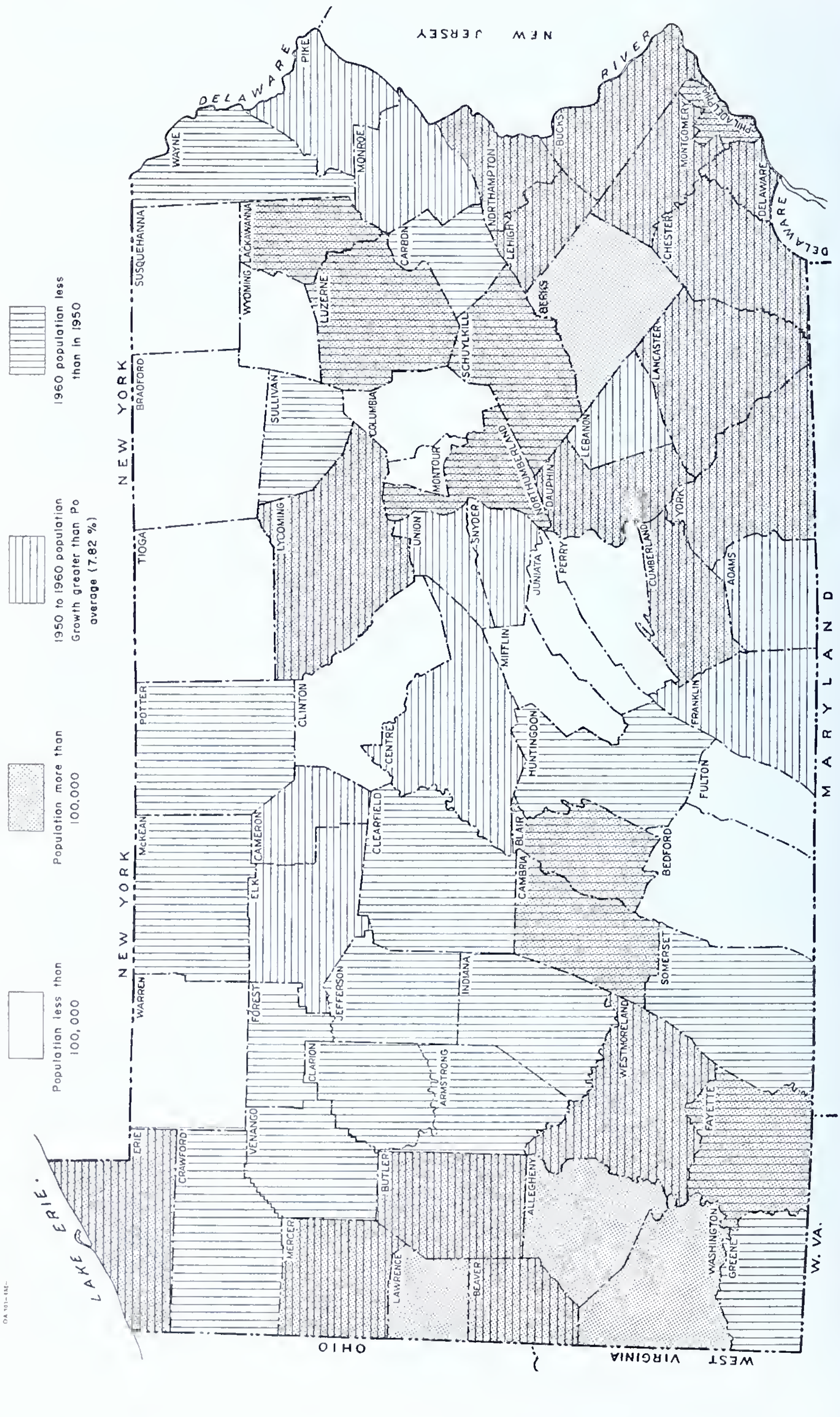

Figure 8. Map of Pennsylvania showing counties having more than 100,000 population, and the rate of growth of the population by county.

USES OF WATER-LEVEL MEASUREMENTS

The uses to which water-level measurements are put may be divided into two categories: (1) those which require only a short period of record and (2) those which require a long record. Short-term records are used chiefly to determine the hydraulic properties of an aquifer by pumping tests, by measurement of cyclic fluctuations such as tides, by measurements of the natural water-level recession in wells, and by measurements of the interrelationship of water levels in wells and those in nearby streams.

The solution of specific problems sometimes requires the collection of water-level data for several years. Such problems may include the effect of dams, stream rerouting, spreading of floodwaters, or irrigation practices on ground-water levels. Also, long records of water-level fluctuations, perhaps even of a continuing nature, are needed to predict streamflow or future ground-water levels.

Statistical analysis of long-term records has been used to estimate the hydraulic properties of aquifers, recharge and discharge rates, evapotranspiration, and soil-moisture storage. The accuracy of the estimates improves as the length of the record increases.

Continuing records are valuable for two other purposes. First, measurements should be made in areas undergoing development in order to ensure that the ground-water supplies are managed properly. Second, measurements should be made also in areas remote from the effects of man—areas that are not likely to be disturbed in the foreseeable future. This second group will furnish information on the natural regimen and serve as a control sample against which the effects of man's activities can be measured.

The uses described above are based upon our present understanding of the hydrologic cycle. Because the science of hydrology is still young, many more basic data need be collected and interpreted. As the inherent character of hydrology is such that these data may vary greatly from year to year, their value increases as the length of the record increases. As our knowledge of the interrelationship of the atmosphere, surface water, and ground water grows, our uses of available information will grow, and the accuracy of predictions based on this information will improve.

REQUISITES OF AN IDEAL OBSERVATION-WELL NETWORK

The ideal network is one which furnishes data on water levels in each of the geologic and climatic environments. In addition, the network should be sensitive to the population distribution of the Commonwealth by including observation wells that will reflect indefinitely

the natural regimen and other wells that will monitor the development of an area by man. When possible, observation wells should be established several years before development is accomplished, so that they will record the transition from a natural to an artificial environment.

The wells should be in hydraulic continuity with the aquifer under study and should be so situated that they reflect adequately the environment they are supposed to sample. They should be coordinated with sites sampling other phases of the environment, and they should be so selected and situated that they may be measured as long as desired.

At the time a well is established as an observation site, it should be pumped to ensure that it is not clogged and to determine (if possible) the hydraulic properties of the aquifer at that point. Unless there are specific reasons for doing otherwise, a well should be at only a moderate height above points of discharge from the aquifer, in order to reduce the seasonal fluctuations and thus minimize the opportunity for clogging. Geologic information, including electric and gamma-ray logs, should be obtained, and the depths to the water-bearing zones should be determined. A water sample from the well should be analyzed to determine its physical and chemical properties.

Each observation well should be equipped with a continuous water-level recording device for a period long enough to determine the characteristics of water-level fluctuations in the well. In addition, periodic checks should be made to determine if the well is becoming clogged, or if the physical or chemical character of the water is changing.

The well should be tightly cased and covered to prevent animals from falling into it, to prevent the direct entrance of surface water, and to prevent its becoming blocked by having stones or other debris thrown into it.

THE NETWORK IN PENNSYLVANIA

As the time, funds, or personnel are seldom available to conduct an ideal observation-well program, the number of wells in any network is necessarily limited. In 1962, the network in Pennsylvania consisted of 47 wells and included only 8 of the 37 wells in the original network established in 1930. The period of record of the wells measured in 1962 ranged from 2 to 32 years. About half the wells had less than 15 years of record. Dug wells constituted 70 percent of those having more than 15 years of record but accounted for only 45 percent of the total number of wells. Most of the measurements have been made at weekly or monthly intervals. However, 12 continuous water-level recorders were in use in 1962. About 40 percent of the wells are in counties having populations greater than 100,000, and 23 percent of the wells are in

urban areas. Five wells in Montgomery County and one well in Chester County, are in or near communities experiencing rapid growth. The rural wells are scattered throughout the Commonwealth and most of them are in places where they will not be disturbed in the foreseeable future.

An observation-well network should sample the many variables and supply as much detailed information as is economically practical. The present network is considered satisfactory in most respects, but several changes will be made.

The dug wells will be replaced by drilled wells because dug wells tend to fill in and become so shallow that they may be dry during drought years. Also, dug wells require constant maintenance to prevent them from becoming safety hazards.

The network will be expanded in those areas undergoing rapid growth, where new or additional demands may be made on the ground-water supply. The wells will be test-pumped to ensure their hydraulic connection to the aquifer prior to their being adopted as observation wells; they will be logged electrically to determine the lithology of the rocks penetrated, and the size, number, and position of the water-bearing zones.

All the wells will be pumped and water samples will be taken for chemical analysis at regular intervals. Continuous water-level recorders will be used on all wells for periods sufficient to establish the fluctuations characteristic of the water level in each well. Following the establishment of the characteristic curve, the water level may be measured weekly, monthly, or at even longer intervals.

Table 1 — Record of observation wells in 1962

Method of construction: Dr, Drilled; Du, Dug. Environment: R, Rural; U, Urban

Well number	County	Owner	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer Name	Aquifer Composition	Geologic period	Static water level April 1962: Depth below land-surface (feet)	Environment	Length of record in years (1962)
Ad-90	Adams	V. G. Rife		584	Du	72	27	9	New Oxford Formation	Sandstone	Triassic	6	R	2
Ar-2	Armstrong	M. J. Cordera	1923	780	Dr	6	82			Sand and gravel	Quaternary	36	R	12
Bd-3	Bedford	W. M. Hoffman		895	Du	60	58		Catskill Formation	Shale	Devonian	49	U	21
Be-4	Berks	Commonwealth of Pennsylvania		694	Du	48	20		Stockton Formation	do.	Triassic	30	R	14
Br-2	Bradford	C. Holon		820	Du	30	64		Chemung Formation	do.	Devonian	30	R	31
Ca-1	Cambria	Tribune Publishing Co.	1940	1,165	Dr	12-8	180	45	Homewood Formation	Sandstone	Pennsylvanian	20	U	10
Cf-4	Clearfield	J. I. McNaul		1,160	Du	60	30		Allegheny Group	Shale and sandstone	do.	20	U	16
Ch-5	Chester	J. D. Hefferman		550	Du	30	12			Quartz Monzonite	Precambrian	2	R	11
Ch-10	do.	R. J. Kleberg, Jr.		300	Dr	6	34		Cockeysville Marble	Marble	do.	12	R	11
Ch-11	do.	J. E. Ryan	Before 1850	540	Du	24	20		Baltimore Gneiss	Gneiss	do.	12	R	12
Ch-152	do.	Phoenix Iron and Steel Co.	1952	85	Dr	12-8	750	35	Stockton Formation	Sandstone	Triassic	Flowing	U	6
Cn-1	Clinton	Commonwealth of Pennsylvania	1940	2,050	Dr	6	78	38	Pottsville Group		Pennsylvanian	48	R	12
Co-1	Columbia	F. E. Walters		490	Du	36	19				Quaternary	11	R	31
Cr-1	Clarion	J. G. Meisinger		1,480	Du	36	28	15	Allegheny Group	Sandstone	Pennsylvanian	14	U	30
Cr-3	do.	Commonwealth of Pennsylvania	1939	1,530	Dr	6	130	12	Pottsville Group	Shale and sandstone	do.	43	R	12

Cu-2	Cumberland	do.	1944	955	Dr	6	37		Ledger Formation	Dolomite	Cambrian	14	U	11
De-3	Delaware	Mrs. Hope W. Ebert		260	Du	42	22		Wissahickon Formation		Precambrian	14	R	12
Ek-1	Elk	F. X. Ernst		1,910	Dr	4	87		Allegheny Group	Shale and sandstone	Ponnsylvanian	11	U	21
Er-1	Erio	Mrs. Grace P. Estes		1,440	Du	48	18			Sand and gravel	Quaternary	12	R	31
Fr-2	Franklin	U. S. Army	1942	694	Dr	8-6	441	60	Stones River Limestone	Limestone	Ordovician	31	U	12
Fu-1	Fulton	Commonwealth of Pennsylvania	1945	1,160	Dr	6	108		Mauch Chunk Formation	Shale and sandstone	Mississippian	3	R	11
Hu-1	Huntingdon	Mrs. Elizabeth B. Schell		720	Dr	6	33		Chemung Formation	Sandstono	Devonian	21	R	31
In-1	Indiana	Commonwealth of Pennsylvania		1,305	Dr	6	198		Conemaugh Formation	Shale and sandstone	Pennsylvanian	75	U	18
Lb-377	Lebanon	Levitz Frozen Foods		460	Dr	8-6	205	30	Ontelaunee Formation	Limestone	Ordovician	7	U	4
Le-158	Lehigh	Francis Degnan	1953	370	Dr	6	76	57	Tomstown Formation	do.	Cambrian	74	U	9
Le-302	do.	Alex Fudali		405	Dr	6	115		do.	do.	do.	100	U	9
Lk-4	Lackawanna	Commonwealth of Pennsylvania		1,910	Du	36	9		Catskill Formation	Shale and sandstone	Devonian	4	R	9
Lu-243	Luzerne	do.	1947	1,280	Dr	6	195	40	do.	do.	do.	54	R	7
Ly-1	Lycoming	do.	1936	2,070	Dr	4½	74		Pottsville Group	do.	Pennsylvanian	21	R	13
Mf-1	Mifflin	C. C. Naginey		680	Du	36	28			Limestone	Ordovician	22	R	16
Mg-2	Montgomery	Commonwealth of Pennsylvania	1752	158	Du	48	30		Brunswick Formation	Shale	Triassic	25	R	9
Mg-101	do.	Doehler-Jarvis Corp.	1936	160	Dr	8	300		do.	do.	do.	58	U	9
Mg-127	do.	Sharp and Dohme, Inc.		351	Dr	12-10	300		do.	do.	do.	72	U	6
Mg-133	do.	Bryn Mawr College	Before 1900	380	Dr	10	350		Wissahickon Formation		Precambrian	16	U	8
Mg-225	do.	Norristown State Hospital	1950	165	Dr	12	300		Stockton Formation	Sandstone	Triassic	29	U	6
Pe-2	Perry	Miss Bertha Demaree		400	Du	36	20		Chemung Formation	Shale and sandstone	Devonian	14	U	31

Table 1 — Record of observation wells in 1962 (Continued)

Method of construction: Dr, Drilled; Du, Dug. Environment: R, Rural; U, Urban

Well number	County	Owner	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer		Geologic period	Static water level April 1962	Environment	Length of record in years (1962)
									Name	Composition		Depth below land-surface (feet)		
Ph-12	Philadelphia	U. S. Navy	1944	10	Dr	8	110	104	Raritan Formation	Sand	Cretaceous	30	U	18
Ph-20	do.	do.	1946	13	Dr	8	266	243	do.	do.	do.	50	U	16
Sc-1	Schuylkill	N. C. Donofrio		560	Du	52	33		Portage Formation	Shale	Devonian	17	R	31
Sc-5	do.	George Mengle		490	Du	36	34		Marcellus Formation	do.	do.	26	R	14
So-2	Somerset	Commonwealth of Pennsylvania	1936	2,037	Dr	4-6	450	310	Pottsville Group	Shale and sandstone	Pennsylvanian	30	R	25
Sq-1	Susquehanna	Carlton Farm		1,690	Du	48	38				Quarternary	4	R	32
Su-1	Sullivan	C. D. Molyneux		1,080	Du	48	28			Sand and gravel	do.	26	R	17
Ti-1	Tioga	Mrs. Ruth Wilson		1,290	Du	30	23			do.	do.	8	R	27
Wn-1	Wayne	A. H. Tyce		920	Du	30	12			do.	do.	7	R	31
Ws-1	Washington	Floyd King		1,190	Du	40	36	4	Washington Formation	Limestone	Permian	18	R	26
Yo-180	York	New York Wire Cloth Co.		360	Dr	8	490		New Oxford Formation	Shale	Triassic	29	R	2
[1]Bk-500	Bucks	Publicker Industries, Inc.	1944	15	Dr	17-12	32			Sand and gravel	Recent		U	
[1]Mg-4	Montgomery	Collegeville and Trappe Boroughs	1936	195	Dr	12-8	275	34	Brunswick Formation	Shale	Triassic		U	

[1]Not part of observation well network in 1962, but included because used in illustrations.